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(21)Application number : 2000-400952

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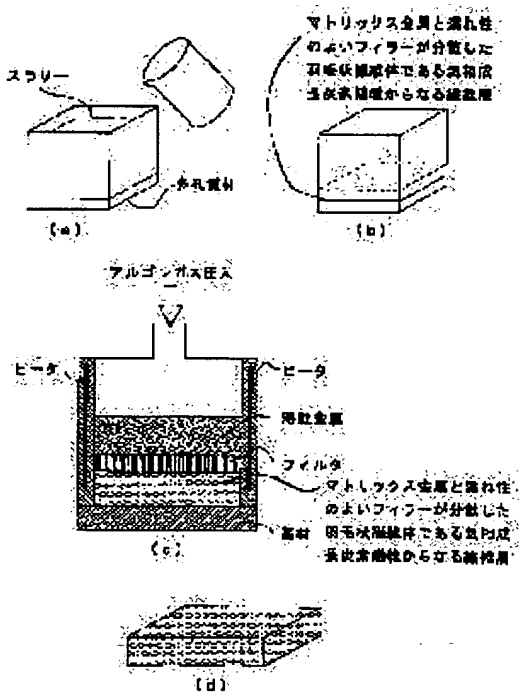
(54) COMPOSITION MATERIAL AND MANUFACTURING METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a light composite material which thoroughly shows inherent high thermal conductivity.

SOLUTION: This composite material comprises vapor-phase epitaxy carbon- fiber and metal, and aluminum borate is added as a filler having wettability to the metal. The manufacturing method comprises forming a fiber layer consisting of vapor-phase epitaxy carbon fiber and aluminum borate, arranging the fiber layer, a filter, and metal in a pressure vessel, subsequently heating the metal to melt, while making the pressure vessel to be in a vacuum condition, and compression impregnating the molten metal into the fiber layer.



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CLAIMS

[Claim(s)]
[Claim 1] Composite material characterized by coming to add said metal and a wettability good filler in the composite material which consists of a vapor growth carbon fiber and a metal.
[Claim 2] Composite material according to claim 1 characterized by for the above-mentioned metal being aluminum or an aluminium alloy, and the above-mentioned filler being boric acid aluminum.
[Claim 3] Composite material according to claim 2 characterized by the above-mentioned boric acid aluminum being a boric acid aluminum whisker.
[Claim 4] Composite material according to claim 1 to 3 with which the above-mentioned vapor growth carbon fiber is characterized by being a feathers-like fiber object.
[Claim 5] The manufacture approach of the composite material which is made to carry out heating melting of the metal while moving to a container, forming the fiber layer which removes the account solvent of Gokami and consists of a vapor growth carbon fiber, laying a fiber layer, a filter, and a metal subsequently to in a pressurized container and making the inside of a pressurized container into a vacua subsequently after distributing a vapor growth carbon fiber and boric acid aluminum to a solvent, and is characterized by making this fiber layer carry out pressurization sinking in of the molten metal.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention makes a metal a matrix and relates to the composite-material technique of having a vapor growth carbon fiber as a filler.
[0002]
[Description of the Prior Art] Since aluminum or an aluminium alloy is excellent in thermal conductivity, it is used for a heat sink etc. and used for local cooling and heat dissipation of CPU etc.
[0003] However, a note type device, a handheld computer device, etc. which cannot use a heat dissipation fan are miniaturized, and while the device lightweight-ized to the degree of pole is developed one after another, the calorific value in these devices is increasing with the increment in the number of clocks (clock frequency) etc. now. In order to satisfy these conflicting requirements, though it is lightweight, the ingredient excellent in thermal conductivity is called for.
[0004] The aluminum or the aluminium alloy with which the carbon fiber was added as a filler as such a thing was known, and this invention persons have proposed the metal system composite material which used the vapor growth carbon fiber as a filler as an ingredient which has high thermal conductivity already especially.
[0005] However, in such a vapor growth carbon fiber-aluminum system composite material, even if the adhesion between a metal and a carbon fiber was bad and provided means, such as reduced pressure, at the time of shaping, the small clearance (henceforth a "void") occurred in the interface, and the outstanding thermal conductivity which should be obtained essentially was not obtained in fact in many cases.
[0006]
[Problem(s) to be Solved by the Invention] This invention improves a trouble, namely, aims lightweight at offering the composite material with which original high thermal conductivity is fully demonstrated.
[0007]
[Means for Solving the Problem] The composite material of this invention is a composite material with which it comes to add said metal and a wettability good filler a passage according to claim 1 in the composite material which consists of a vapor growth carbon fiber and a metal in order to solve the above-mentioned technical problem.
[0008] Moreover, a passage according to claim 5, after the manufacture approach of the composite material of this invention distributes a vapor growth carbon fiber and boric acid aluminum to a solvent, it is moved to a container. It is the manufacture approach of composite material of forming the fiber layer which removes the account solvent of Gokami and consists of a vapor growth carbon fiber, laying a fiber layer, a filter, and a metal subsequently to in a pressurized container, carrying out heating melting of the metal while making the inside of a pressurized container into a vacua subsequently, and making this fiber layer carrying out pressurization sinking in of the molten metal.
[0009]
[Embodiment of the Invention] In order that the composite material of this invention may use a thermally conductive good vapor growth carbon fiber (henceforth "VGCF") extremely, when it considers as composite material, the outstanding thermal conductivity is obtained.
[0010] Although the thing of the needle crystal called whisker is known by the vapor growth carbon fiber used with the composite material of this invention, it is single dimension-like [these / a configuration] and, generally the control of what needs to control the direction of orientation if in charge of shaping of the composite material used for three-dimensions-applications, such as heat dissipation, is difficult.

[0011] The carbon fiber of continuous glass fibers similarly known as a carbon fiber of a single dimension configuration, such as a polyacrylonitrile system carbon fiber and a pitch based carbon fiber, in addition, chop-izing, Or although what was Mild-ized (it does not become powder completely even if it Mild-izes by the usual approach, but the configuration as fiber is maintained) has the same geometrical fault These are further compared with a vapor growth carbon fiber. Since thermal conductivity is low several steps (it is 1 - 600 w/mK extent at these PAN(s) system and a pitch based carbon fiber to the heat conductivity of a vapor growth carbon fiber being 1500 w/mK extent), Even if it forms composite material with aluminum (thermal conductivity is 200 - 270 w/mK), thermally conductive improvement is small.
[0012] Moreover, in the composite material (refer to drawing 7) which has the textiles which consist of a carbon fiber (a pitch based carbon fiber and a polyacrylonitrile system carbon fiber are known) of the conventional continuous glass fiber inside, it is two-dimensional in the direction of fiber, therefore thermal conductivity is also directive, and although it is good two-dimensional,-dimensional [1] or the thermal conductivity can be satisfied with three-dimensions-evaluation of thermal conductivity is not obtained. Furthermore, although the so-called use of 3D textiles (solid textiles) etc. is also possible, a difficult top, it is very expensive to consider as the pack density from which sufficient effectiveness is acquired, and such textiles do not have it. [practical]
[0013] For this reason, it is desirable that it is the vapor growth carbon fiber which is a feathers-like fiber object as a vapor growth carbon fiber used with the composite material of this invention. Specific gravity is before and after 2.0 (the specific gravity of aluminum is 2.7), and the vapor growth carbon fiber which is a feathers-like fiber object here has branching (branching), has deflection by the location, has the vena contracta depending on the case, and twines itself or mutually, there is, and it serves as a fiber lump with an unfixed configuration of 0.03mm - 1mm as a whole.
[0014] Since the vapor growth carbon fiber which is a feathers-like fiber object has branching and heat conducts through that three-dimensions-network, when this thing is made into a filler, composite material with thermal conductivity good in three dimensions is obtained extremely. In addition, the transmission electron microscope photograph was shown for the scanning electron microscope photograph of the vapor growth carbon fiber which is the feathers-like fiber object which it has such deflection in drawing 1 and drawing 2 , and there is vena contracta depending on the case, and twines [oneself or] each other in drawing 3 .
[0015] The vapor growth carbon fiber which is such a feathers-like fiber object can be obtained by the almost same approach as a general needlelike vapor growth carbon fiber. That is, hydrocarbons, such as benzene, are made into carbon supply origin, and it carries out vapor growth under hydrogen existence, using iron as a nucleus. At this time, the vapor growth carbon fiber which is the feathers-like fiber object which it has branching (branching), and has deflection by the location, and there is vena contracta depending on the case, and twines itself or mutually can be obtained by changing conditions, such as temperature, ambient pressure force, and the hydrocarbon amount of supply of a raw material. At this time, two or more feathers-like fiber objects twine each other, and form the fiber lump. In addition, in producing a vapor growth carbon fiber conventionally, these conditions were set up so that what does not have branching, deflection, etc. might be obtained supposing using for the usual application, such as obtaining a mechanical strength.
[0016] It is desirable that the meaning of this invention to thermal conductivity is high, and specific gravity's is low as a metal used as a matrix with the composite material of this invention. That is, aluminum, various aluminium alloys, magnesium, or a Magnesium alloy is mentioned.
[0017] In the composite material of this invention, the wettability in the interface of a vapor growth carbon fiber and the metal which is a matrix also improves specifically by adding this metal and the wettability good filler other than the metal which is the vapor growth carbon fiber and matrix which are these fillers as the 2nd filler. Consequently, the thermal conductivity as a composite material also improves and various, still more mechanical engine performance improves remarkably.
[0018] When the metal which is a matrix is aluminum or an aluminium alloy, it is desirable to use boric acid aluminum as these and a wettability good filler. Furthermore, homogeneity distribution is easy in boric acid aluminum being a whisker, and the effectiveness of this invention is uniformly acquired with the whole composite material of a product. Such a boric acid aluminum whisker can come to hand from Shikoku Chemicals etc.
[0019] The composite material of this invention can be obtained as follows, for example. If the vapor growth carbon fiber which is a feathers-like fiber object is delicate, it is weak and stress works, it will collapse easily and a three-dimensions-network will be easy to be lost. Therefore, organic solvents (a mixed solvent may be used) (these are collectively called "solvent"), such as water or alcohols, and ketones, are distributed. The chemical which adds a metal and a wettability good filler and raises dispersibility, such as a surfactant, if needed

at this time is added. As the shape of a slurry It flows into the container which consists of porosity material (a filter paper or porosity ceramic) in which a pars basilaris ossis occipitalis has liquid permeability (refer to drawing 4 (a)), and a solvent is removed after that. Like drawing 4 (b) A matrix metal, the metal which the wettability good filler distributed, and a wettability good filler form the fiber layer which consists of a vapor growth carbon fiber which is a feathers-like fiber object.

[0020] It moves to the container (pressurized container) with which the heater as shows this fiber layer to drawing 4 (c) was formed and in which pressurization and decompression are possible. The pars basilaris ossis occipitalis (inside of drawing "base material") of this pressurized container is dismountable so that it may mention later.

[0021] The laminating of the metal (solid) is carried out the filter which consists of a porous material (here porosity ceramic) which has thermal resistance on such a fiber layer, and on this filter. Thus, after laying a fiber layer, a filter, and a metal in a pressurized container, Heating melting of the above-mentioned metal is carried out at the heater which is attached to a container while making the inside of a pressurized container into a vacua. After the molten metal which penetrated the filter is introduced in a container, the inside of a container is pressurized using inactive gas, argon gas, etc. to the molten metal and carbon used as a matrix (in this example, it pressurizes by argon gas), and a fiber layer is made to carry out pressurization sinking in, using molten metal as a matrix component.

[0022] Then, heating at the heater of a container is stopped, a system is cooled, a metal is solidified, and the composite material which removes the base material of a container pars basilaris ossis occipitalis after radiationnal cooling, and consists of a vapor growth carbon fiber which is the acquired feathers-like fiber object, and a metal is taken out.

[0023] Thus, by sinking in molten metal under the inactive-gas-pressure force, though the molten metal which is easy to oxidize is used, a good composite material is obtained. In addition, since the matrix metal and the wettability good filler other than a matrix metal and a vapor growth carbon fiber are added by this configuration, in it, wettability with the matrix metal of a vapor growth carbon fiber can improve by leaps and bounds, and in it, a good composite material which does not have an opening (void) in these both interface, either can be obtained.

[0024] In addition, without a matrix component increasing superfluously, since the composite material obtained in order vertical movement within a pressurized container is possible for the above-mentioned filter and to keep the space under it the optimal hardly produces destruction of the vapor-growth carbon fiber which is a feathers-like fiber object, either, the heat-conduction disposition top effectiveness by the vapor-growth carbon fiber which is this feathers-like fiber object, and lightweight-ized effectiveness can fully demonstrate it.

[0025] Moreover, by changing the configuration of a base material and porous ceramics in the above, it can carry out to a ****** configuration, for example, the configuration where it was suitable as a heat sink, and post processing which prepares a configuration can be made unnecessary, or such post processing can be made easy.

[0026] In addition, according to the manufacture approach of the above-mentioned composite material, conventionally, FRM (fiber reinforced metal) with the larger specific gravity of the matrix which was difficult to manufacture than the specific gravity of reinforcement can be obtained easily, and it excels in the dispersibility of a vapor growth carbon fiber then, and becomes an outstanding composite material with few voids with little dispersion in various engine performance (a heat-conducting characteristic, conductivity, reinforcement, elasticity, etc.) and directivity. In addition, the manufacture approach of the composite material concerning above-mentioned this invention is applicable also like manufacture of the composite material which makes a filler the usual vapor growth carbon fiber besides the vapor growth carbon fiber which is a feathers-like fiber object.

[0027]

[Example] By the approach explained above here, the vapor growth carbon fiber which is a feathers-like fiber object 6 % of the weight, As a matrix metal, as a filler with good wettability with 88 % of the weight and aluminum, aluminum is used so that it may become 6 % of the weight about a boric acid aluminum whisker. Distribute the vapor growth carbon fiber and boric acid aluminum whisker which are a feathers-like fiber object, using ethyl alcohol as a solvent at the time of distribution, and it considers as the shape of a slurry. After the pars basilaris ossis occipitalis moved this to the container which consists of porosity material which has liquid permeability, the alcohol which remained was heated and evaporated and, subsequently to this invention, the composite material A of the example which starts in argon atmosphere was produced. Moreover, the wettability with aluminum produced the composite material B of the example of a comparison similarly, without adding good boric

acid aluminum. The cross section of these composite material A and B was observed with the electron microscope. The result at that time was shown in drawing 5 (a) and drawing 6 (a), respectively.
[0028] In these drawing 5 (a) and drawing 6 (a), the highlights section (however, part except the photography data of these drawings lower part) is the void generated in the interface of fiber and a matrix.
[0029] Here, drawing in which having performed the respectively same image processing as these drawing 5 (a) and drawing 6 (a), and having shown distribution of drawing 5 (a) and the highlights section of drawing 6 (a) by the sunspot is shown in drawing 5 (b) and drawing 6 (b), respectively. In the composite material A applied to this invention with these Figs., he can understand that the void between fiber and a matrix has decreased extremely compared with the composite material B concerning the conventional technique.
[0030]
[Effect of the Invention] The composite material of this invention is a composite material excellent also in the mechanical strength which is lightweight, and has good thermal conductivity without directivity, and has a vapor growth carbon fiber as a filler, and can demonstrate the outstanding thermal conductivity perfectly.
[0031] Moreover, even if the manufacture approach of the composite material of this invention uses a weak delicate filler smaller [specific gravity] than a matrix component, it is excellent in distribution of a filler and can obtain an outstanding composite material with little dispersion in various engine performance and directivity (fiber reinforced metal) without a void.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention makes a metal a matrix and relates to the composite-material technique of having a vapor growth carbon fiber as a filler.

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PRIOR ART

[Description of the Prior Art] Since aluminum or an aluminium alloy is excellent in thermal conductivity, it is used for a heat sink etc. and used for local cooling and heat dissipation of CPU etc.
[0003] However, a note type device, a handheld computer device, etc. which cannot use a heat dissipation fan are miniaturized, and while the device lightweight-ized to the degree of pole is developed one after another, the calorific value in these devices is increasing with the increment in the number of clocks (clock frequency) etc. now. In order to satisfy these conflicting requirements, though it is lightweight, the ingredient excellent in thermal conductivity is called for.
[0004] The aluminum or the aluminium alloy with which the carbon fiber was added as a filler as such a thing was known, and this invention persons have proposed the metal system composite material which used the vapor growth carbon fiber as a filler as an ingredient which has high thermal conductivity already especially.
[0005] However, in such a vapor growth carbon fiber-aluminum system composite material, even if the adhesion between a metal and a carbon fiber was bad and provided means, such as reduced pressure, at the time of shaping, the small clearance (henceforth a "void") occurred in the interface, and the outstanding thermal conductivity which should be obtained essentially was not obtained in fact in many cases.

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EFFECT OF THE INVENTION

[Effect of the Invention] The composite material of this invention is a composite material excellent also in the mechanical strength which is lightweight, and has good thermal conductivity without directivity, and has a vapor growth carbon fiber as a filler, and can demonstrate the outstanding thermal conductivity perfectly.
[0031] Moreover, even if the manufacture approach of the composite material of this invention uses a weak delicate filler smaller [specific gravity] than a matrix component, it is excellent in distribution of a filler and can obtain an outstanding composite material with little dispersion in various engine performance and directivity (fiber reinforced metal) without a void.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention improves a trouble, namely, aims lightweight at offering the composite material with which original high thermal conductivity is fully demonstrated.

[Translation done.]

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MEANS

[Means for Solving the Problem] The composite material of this invention is a composite material with which it comes to add said metal and a wettability good filler a passage according to claim 1 in the composite material which consists of a vapor growth carbon fiber and a metal in order to solve the above-mentioned technical problem.
[0008] Moreover, a passage according to claim 5, after the manufacture approach of the composite material of this invention distributes a vapor growth carbon fiber and boric acid aluminum to a solvent, it is moved to a container. It is the manufacture approach of composite material of forming the fiber layer which removes the account solvent of Gokami and consists of a vapor growth carbon fiber, laying a fiber layer, a filter, and a metal subsequently to in a pressurized container, carrying out heating melting of the metal while making the inside of a pressurized container into a vacua subsequently, and making this fiber layer carrying out pressurization sinking in of the molten metal.
[0009]
[Embodiment of the Invention] In order that the composite material of this invention may use a thermally conductive good vapor growth carbon fiber (henceforth "VGCF") extremely, when it considers as composite material, the outstanding thermal conductivity is obtained.
[0010] Although the thing of the needle crystal called whisker is known by the vapor growth carbon fiber used with the composite material of this invention, it is single dimension-like [these / a configuration] and, generally the control of what needs to control the direction of orientation if in charge of shaping of the composite material used for three-dimensions-applications, such as heat dissipation, is difficult.
[0011]

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EXAMPLE

[Example] By the approach explained above here, the vapor growth carbon fiber which is a feathers-like fiber object 6 % of the weight, As a matrix metal, as a filler with good wettability with 88 % of the weight and aluminum, aluminum is used so that it may become 6 % of the weight about a boric acid aluminum whisker. Distribute the vapor growth carbon fiber and boric acid aluminum whisker which are a feathers-like fiber object, using ethyl alcohol as a solvent at the time of distribution, and it considers as the shape of a slurry. After the pars basilaris ossis occipitalis moved this to the container which consists of porosity material which has liquid permeability, the alcohol which remained was heated and evaporated and, subsequently to this invention, the composite material A of the example which starts in argon atmosphere was produced. Moreover, the wettability with aluminum produced the composite material B of the example of a comparison similarly, without adding good boric acid aluminum. The cross section of these composite material A and B was observed with the electron microscope. The result at that time was shown in drawing 5 (a) and drawing 6 (a), respectively.
[0028] In these drawing 5 (a) and drawing 6 (a), the highlights section (however, part except the photography data of these drawings lower part) is the void generated in the interface of fiber and a matrix.
[0029] Here, drawing in which having performed the respectively same image processing as these drawing 5 (a) and drawing 6 (a), and having shown distribution of drawing 5 (a) and the highlights section of drawing 6 (a) by the sunspot is shown in drawing 5 (b) and drawing 6 (b), respectively. In the composite material A applied to this invention with these Figs., he can understand that the void between fiber and a matrix has decreased extremely compared with the composite material B concerning the conventional technique.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the scanning electron microscope photograph of the vapor growth carbon fiber which is a feathers-like fiber object.
[Drawing 2] They are other scanning electron microscope photographs of the vapor growth carbon fiber which is a feathers-like fiber object.
[Drawing 3] It is the transmission electron microscope photograph of the vapor growth carbon fiber which is a feathers-like fiber object.
[Drawing 4] It is drawing showing an example of the approach of producing the composite material of this invention.
(a) It is drawing (model Fig.) showing the condition of filling a container with the slurry which distributed to the solvent the vapor growth carbon fiber which is a feathers-like fiber object.
It is drawing (model Fig.) showing that the fiber layer which consists of a vapor growth carbon fiber which is a feathers-like fiber object within the container of (b) and (a) was formed.
(c) It is the model sectional view showing the condition of infiltrating molten metal into the above-mentioned fiber layer.
(d) It is drawing (model Fig.) showing the composite material (composite material which consists of a vapor growth carbon fiber which is a feathers-like fiber object, and a metal) concerning this invention.
[Drawing 5] (a) It is the electron microscope photograph of the cross section of the composite material A concerning this invention.
It is drawing having shown distribution of the highlights section (it is a void except photography data division) of (b) and (a).
[Drawing 6] (a) It is the electron microscope photograph of the cross section of the composite material B concerning the conventional technique.
It is drawing having shown distribution of the highlights section (it is a void except photography data division) of (b) and (a).
[Drawing 7] It is drawing (model Fig.) showing the composite material which has as a filler the textiles which consist of a continuous glass fiber carbon fiber.

[Translation done.]

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Ｃ２２Ｃ　47/06		Ｃ２２Ｃ　47/06	４Ｋ０２０
47/08		47/08	
49/06		49/06	
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101:10）		101:10）	

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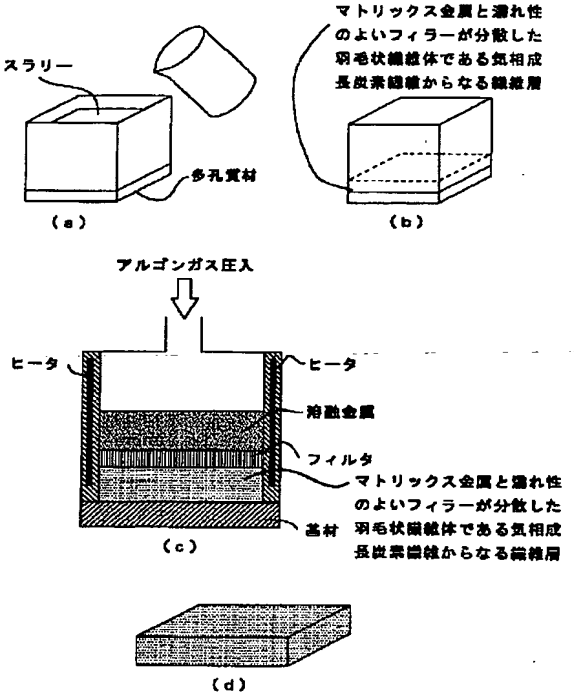
Ｆターム(参考)　4K020 AA02 AA04 AA12 AC01 BA06
BB04

(54)【発明の名称】　複合材料及びその製造方法

(57)【要約】　（修正有）
【課題】　軽量で、かつ、本来の高い熱伝導性が充分に発揮される複合材料を提供する。
【解決手段】　気相成長炭素繊維と金属とからなる複合材料において、金属と濡れ性の良いフィラーとして硼酸アルミニウムが添加されてなる複合材料で、気相成長炭素繊維及び硼酸アルミニウムとからなる繊維層を形成し、圧力容器内に繊維層、フィルタ、金属を載置し、次いで圧力容器内を真空状態とするとともに金属を加熱溶融させ、該繊維層に溶融金属を加圧含浸させる。



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【特許請求の範囲】

【請求項１】　気相成長炭素繊維と金属とからなる複合材料において前記金属と濡れ性の良いフィラーが添加されてなることを特徴とする複合材料。

【請求項２】　上記金属がアルミニウムまたはアルミニウム合金であり、かつ、上記フィラーが硼酸アルミニウムであることを特徴とする請求項１に記載の複合材料。

【請求項３】　上記硼酸アルミニウムが硼酸アルミニウムウィスカであることを特徴とする請求項２に記載の複合材料。

【請求項４】　上記気相成長炭素繊維が、羽毛状繊維体であることを特徴とする請求項１ないし請求項３のいずれかに記載の複合材料。

【請求項５】　気相成長炭素繊維及び硼酸アルミニウムを溶媒に分散した後容器に移し、その後上記溶媒を除去して気相成長炭素繊維からなる繊維層を形成し、次いで圧力容器内に繊維層、フィルタ、金属を載置し、次いで圧力容器内を真空状態とするとともに金属を加熱溶融させ、該繊維層に溶融金属を加圧含浸させることを特徴とする複合材料の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、金属をマトリックスとし、フィラーとして気相成長炭素繊維を有する複合材料技術に関する。

【０００２】

【従来の技術】アルミニウム、あるいは、アルミニウム合金は熱伝導性に優れているので、ヒートシンクなどに用いられ、ＣＰＵなどの局所的な冷却・放熱に用いられている。

【０００３】しかしながら、現在、放熱ファンを用いることのできないノート型機器、ハンドヘルド機器など小型化し、極度に軽量化した機器が次々と開発される一方、クロック数（動作周波数）の増加などに伴い、これら機器での発熱量が増大している。これら矛盾する要求を満足するため、軽量でありながら熱伝導性に優れた材料が求められている。

【０００４】このようなものとして炭素繊維がフィラーとして添加されたアルミニウムあるいはアルミニウム合金が知られ、本発明者らはすでに、特に高い熱伝導性を有する材料として、気相成長炭素繊維をフィラーとして用いた金属系複合材料を提案してきた。

【０００５】しかしこのような気相成長炭素繊維－アルミニウム系複合材料では、金属と炭素繊維との間の密着性が悪く、成形時に減圧などの手段を講じても界面に小さな隙間（以下、「ボイド」とも云う）が発生し、本来得られるべき優れた熱伝導性が実際には得られない場合が多かった。

【０００６】

【発明が解決しようとする課題】本発明は、問題点を改善する、すなわち、軽量で、かつ、本来の高い熱伝導性が充分に発揮される複合材料を提供することを目的とする。

2

【０００７】

【課題を解決するための手段】本発明の複合材料は上記課題を解決するため、請求項１に記載の通り、気相成長炭素繊維と金属とからなる複合材料において前記金属と濡れ性の良いフィラーが添加されてなる複合材料である。

【０００８】また、本発明の複合材料の製造方法は、請求項５に記載の通り、気相成長炭素繊維及び硼酸アルミニウムを溶媒に分散した後容器に移し、その後上記溶媒を除去して気相成長炭素繊維からなる繊維層を形成し、次いで圧力容器内に繊維層、フィルタ、金属を載置し、次いで圧力容器内を真空状態とするとともに金属を加熱溶融させ、該繊維層に溶融金属を加圧含浸させる複合材料の製造方法である。

【０００９】

【発明の実施の形態】本発明の複合材料は極めて熱伝導性の良好な気相成長炭素繊維（以下「ＶＧＣＦ」とも云う）を用いるため、複合材料とした場合、優れた熱伝導性が得られる。

【００１０】本発明の複合材料で用いる気相成長炭素繊維にはウィスカと云われる針状結晶のものが知られているが、これらは形状が一次元的であり、放熱などの三次元的用途に用いる複合材料の成形に当たってはその配向方向を制御する必要があるものの、その制御は一般に困難である。

【００１１】なお、同様に一次元形状の炭素繊維として知られる、ポリアクリロニトリル系炭素繊維やピッチ系炭素繊維などの長繊維の炭素繊維をチョップ化、或いはミルド化（通常の方法でミルド化しても完全には粉状にならず、繊維としての形状は保たれる）したものも同様の形状的欠点を有するが、これらは更に、気相成長炭素繊維に比べて熱伝導性が数段低い（気相成長炭素繊維の熱伝導率が１５００ｗ／ｍＫ程度であるのに対し、これらＰＡＮ系及びピッチ系炭素繊維では１～６００ｗ／ｍＫ程度）ため、アルミニウム（熱伝導性は２００～２７０ｗ／ｍＫ）との複合材料を形成しても、熱伝導性の向上は小さい。

【００１２】また、従来の長繊維の炭素繊維（ピッチ系炭素繊維及びポリアクリロニトリル系炭素繊維が知られる）からなる織物を内部に有する複合材料（図７参照）では繊維の方向が二次元的であり、そのため熱伝導性も方向性があって１次元あるいは二次元的には良好であるが、三次元的な評価では満足できる熱伝導性が得られない。さらに、いわゆる３Ｄ織物（立体織物）などの使用も可能ではあるものの、充分な効果が得られる充填密度とすることが困難な上、このような織物は極めて高価であり実用的でない。

【００１３】このため、本発明の複合材料で用いる気相成長炭素繊維としては羽毛状繊維体である気相成長炭素繊維であることが望ましい。ここで羽毛状繊維体である気相成長炭素繊維は比重が２．０前後（アルミニウムの比重は２．７）であって、枝分かれ（分岐）を有し、場所によって曲がりを有し、場合によってはくびれがあり、また、自ら或いは互いに絡まりあって、全体として０．０３ｍｍ～１ｍｍの不定な形状の繊維塊となっているものである。

【００１４】羽毛状繊維体である気相成長炭素繊維は枝分かれがあるため、その三次元的ネットワークを通じて熱が伝導されるため、このものをフィラーとした場合に極めて三次元的に熱伝導性が良好な複合材料が得られる。なお、図１及び図２にこのような曲がりを有し、場合によってはくびれがあり、また、自ら或いは互いに絡まり合う羽毛状繊維体である気相成長炭素繊維の走査型電子顕微鏡写真を、図３には透過型電子顕微鏡写真を示した。

【００１５】このような羽毛状繊維体である気相成長炭素繊維は、一般的な針状の気相成長炭素繊維とほぼ同様の方法によって得ることができる。すなわち、ベンゼンなどの炭化水素を炭素供給元とし、水素存在下で鉄を核として気相成長させる。このとき、温度、雰囲気圧力、原料の炭化水素供給量等条件を変化させることにより、枝分かれ（分岐）を有し、場所によって曲がりを有し、場合によってはくびれがあり、また、自ら或いは互いに絡まる羽毛状繊維体である気相成長炭素繊維を得ることができる。このとき、複数の羽毛状繊維体は互いに絡まり合って、繊維塊を形成している。なお、従来、気相成長炭素繊維を作製するに当たっては、機械的強度を得るなど通常の用途に使うことを想定し、枝分かれ、曲がりなどを有しないものが得られるよう、これら条件を設定していた。

【００１６】本発明の複合材料でマトリックスとして用いる金属としては、本発明の趣旨から、熱伝導性が高く、かつ、比重の低いものであることが好ましい。すなわち、アルミニウム、各種アルミニウム合金、マグネシウム、或いは、マグネシウム合金等が挙げられる。

【００１７】本発明の複合材料ではこれらフィラーである気相成長炭素繊維及びマトリックスである金属の他に、第２のフィラーとして、この金属と濡れ性の良いフィラーを添加することにより、気相成長炭素繊維とマトリックスである金属との界面での濡れ性も特異的に向上する。その結果、複合材料としての熱伝導性も向上し、さらに機械的な各種性能が著しく向上する。

【００１８】マトリックスである金属がアルミニウムまたはアルミニウム合金の場合には、これらと濡れ性の良いフィラーとして硼酸アルミニウムを用いることが望ましい。さらに、硼酸アルミニウムがウィスカであると、均一分散が容易で、本発明の効果が製品の複合材料全体でむらなく得られる。このような硼酸アルミニウムウィスカは四国化成工業などから入手が可能である。

【００１９】本発明の複合材料は、例えば次のようにして得ることができる。羽毛状繊維体である気相成長炭素繊維は繊細で脆く、応力が働くと容易に崩れ、三次元的なネットワークが失われやすい。そのため、水、あるいはアルコール類、ケトン類などの有機溶媒（混合溶媒を用いても良い）（これらを併せて「溶媒」と云う）に分散させる。このとき、金属と濡れ性の良いフィラーを添加し、また、必要に応じて界面活性剤など分散性を向上させる薬品を添加し、スラリー状として、底部が液透過性を有する多孔質材（濾紙、あるいは多孔質セラミック等）からなる容器に注ぎ（図４（ａ）参照）、その後溶媒を除去して、図４（ｂ）のように、マトリックス金属と濡れ性のよいフィラーが分散した金属と濡れ性の良いフィラーが羽毛状繊維体である気相成長炭素繊維からなる繊維層を形成する。

【００２０】この繊維層を図４（ｃ）に示すようなヒータが設けられた加減圧可能な容器（圧力容器）に移す。この圧力容器の底部（図中「基材」）は後述するように取り外し可能となっている。

【００２１】このような繊維層の上に耐熱性を有する多孔質材料（ここでは多孔質セラミック）からなるフィルタ、このフィルタの上に金属（固形）を積層する。このように圧力容器内に繊維層、フィルタ及び金属を載置したのち、圧力容器内を真空状態とするとともに容器に付属するヒータにより上記金属を加熱溶融させ、フィルタを透過した溶融金属が容器内に導入された後、容器内をマトリックスとなる溶融金属及び炭素に対して不活性なガス、アルゴンガス等を用いて加圧し（この例ではアルゴンガスにより加圧）、繊維層に溶融金属をマトリックス成分として加圧含浸させる。

【００２２】その後、容器のヒータによる加熱を中止し、系を冷やして金属を固化させ、放冷後、容器底部の基材を外し、得られた羽毛状繊維体である気相成長炭素繊維と金属とからなる複合材料を取り出す。

【００２３】このように不活性ガス圧力下で溶融金属の含浸を行うことにより、酸化されやすい溶融金属を用いながらも良好な複合材料が得られる。なお、この構成には、マトリックス金属及び気相成長炭素繊維の他にマトリックス金属と濡れ性の良いフィラーが添加されているために気相成長炭素繊維のマトリックス金属との濡れ性が飛躍的に向上し、この両者の界面にも空隙（ボイド）のない良好な複合材料を得ることができる。

【００２４】なお、上記フィルタは圧力容器内で上下動可能となっていて、その下の空間を最適に保つため、得られる複合材料は不必要にマトリックス成分が多くなることなく、また、羽毛状繊維体である気相成長炭素繊維の破壊もほとんど生じないため、この羽毛状繊維体である気相成長炭素繊維による熱伝導性向上効果、及び、軽

量化効果が充分に発揮できるものとなる。

【００２５】また、上記において基材及び多孔質セラミックスの形状を変えることにより、様座な形状、例えばヒートシンクとして適した形状とすることができ、形状を整える後加工を不要としたり、或いは、そのような後加工を容易なものとすることができる。

【００２６】なお、上記複合材料の製造方法によれば、従来、製造が困難であったマトリックスの比重が強化材の比重より大きいＦＲＭ（繊維強化金属）を容易に得ることができ、また、そのとき、気相成長炭素繊維の分散性に優れ、各種性能（伝熱特性、伝導率、強度、弾性等）のばらつき、方向性の少ない、ボイドの少ない優れた複合材料となる。なお、上記本発明に係る複合材料の製造方法は、羽毛状繊維体である気相成長炭素繊維の他、通常の気相成長炭素繊維をフィラーとする複合材料の製造にも同様に応用できる。

【００２７】

【実施例】ここで上記で説明した方法で、羽毛状繊維体である気相成長炭素繊維を６重量％、マトリックス金属としてアルミニウムを８８重量％、アルミニウムとの濡れ性が良好なフィラーとして硼酸アルミニウムウィスカを６重量％となるように用い、分散時の溶媒としてエチルアルコールを用いて羽毛状繊維体である気相成長炭素繊維と硼酸アルミニウムウィスカとを分散してスラリー状とし、これを底部が液透過性を有する多孔質材からなる容器に移した後、残留したアルコールを加熱・蒸発させ、次いで、アルゴン雰囲気中で本発明に係る実施例の複合材料Ａを作製した。また、同様に、ただしアルミニウムとの濡れ性が良好な硼酸アルミニウムを添加せずに比較例の複合材料Ｂを作製した。これら複合材料Ａ及びＢの断面を電子顕微鏡で観察した。そのときの結果をそれぞれ図５（ａ）及び図６（ａ）に示した。

【００２８】これら図５（ａ）及び図６（ａ）において、ハイライト部（ただし、これら図面下方の撮影データを除く部分）が繊維とマトリックスとの界面に発生したボイドである。

【００２９】ここで、これら図５（ａ）及び図６（ａ）にそれぞれ同じ画像処理を施して図５（ａ）及び図６（ａ）のハイライト部の分布を黒点で示した図を、それぞれ図５（ｂ）及び図６（ｂ）に示す。これら図により本発明に係る複合材料Ａでは従来技術に係る複合材料Ｂと比べ、繊維とマトリックスとの間のボイドが極めて少＊なくなっていることが理解できる。

【００３０】

【発明の効果】本発明の複合材料は、軽量で方向性のない良好な熱伝導性を有し、また気相成長炭素繊維をフィラーとして有し、その優れた熱伝導性を十全に発揮することができる機械的強度にも優れた複合材料である。

【００３１】また、本発明の複合材料の製造方法は、マトリックス成分よりも比重が小さく、かつ、脆い繊細なフィラーを用いても、フィラーの分散に優れ、各種性能のばらつき、方向性の少ない優れた複合材料（繊維強化金属）を、ボイドなしで得ることができる。

【図面の簡単な説明】

【図１】羽毛状繊維体である気相成長炭素繊維の走査型電子顕微鏡写真である。

【図２】羽毛状繊維体である気相成長炭素繊維の他の走査型電子顕微鏡写真である。

【図３】羽毛状繊維体である気相成長炭素繊維の透過型電子顕微鏡写真である。

【図４】本発明の複合材料を作製する方法の一例を示す図である。

（ａ）羽毛状繊維体である気相成長炭素繊維を溶媒に分散したスラリーを容器に注ぐ状態を示す図（モデル図）である。

（ｂ）（ａ）の容器内で羽毛状繊維体である気相成長炭素繊維からなる繊維層が形成されたことを示す図（モデル図）である。

（ｃ）上記繊維層に溶融金属を含浸させる状態を示すモデル断面図である。

（ｄ）本発明に係る複合材料（羽毛状繊維体である気相成長炭素繊維と金属とからなる複合材料）を示す図（モデル図）である。

【図５】（ａ）本発明に係る複合材料Ａの断面の電子顕微鏡写真である。

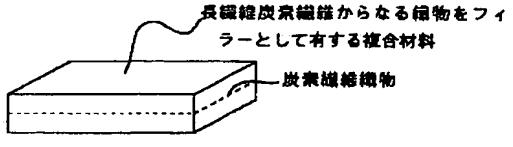
（ｂ）（ａ）のハイライト部（撮影データ部以外はボイド）の分布を示した図である。

【図６】（ａ）従来技術に係る複合材料Ｂの断面の電子顕微鏡写真である。

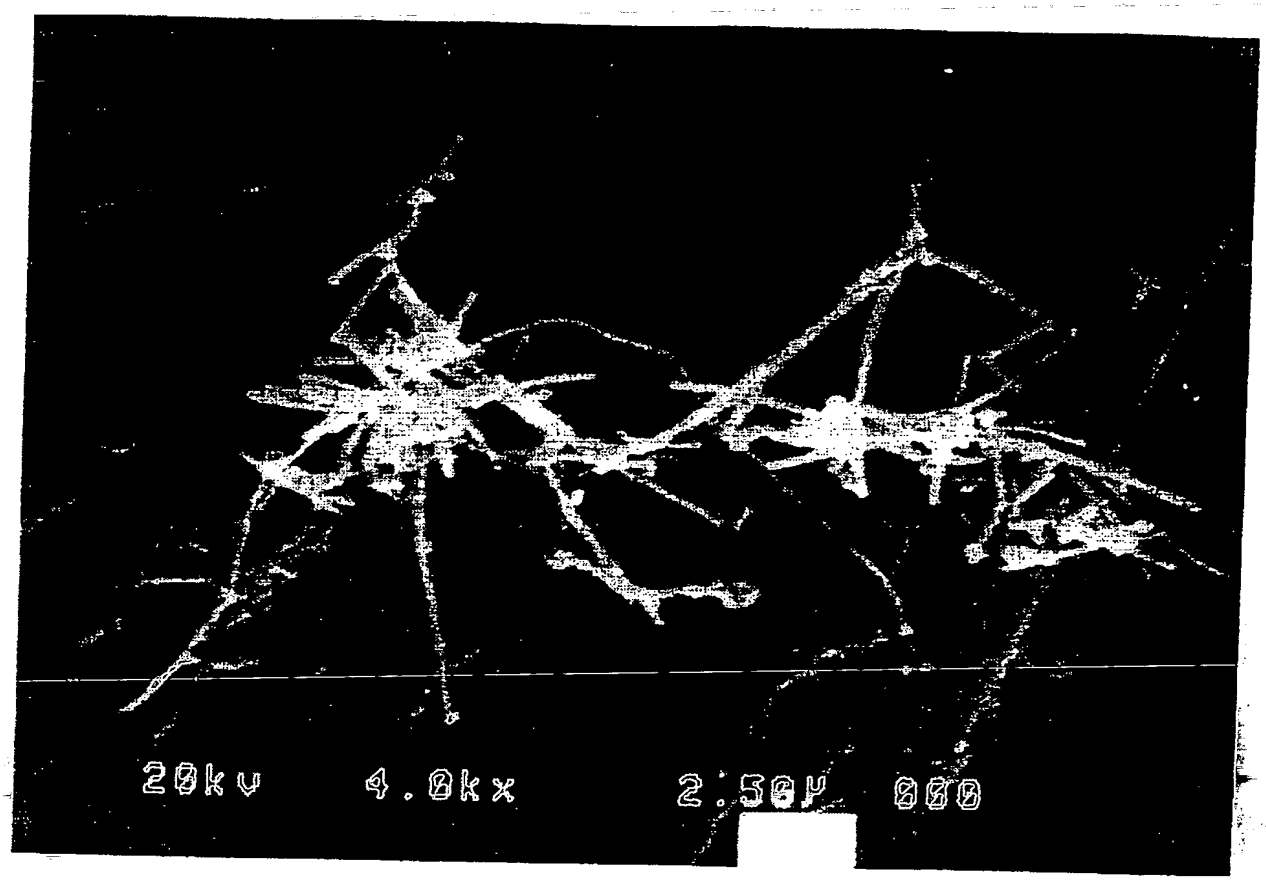
（ｂ）（ａ）のハイライト部（撮影データ部以外はボイド）の分布を示した図である。

【図７】長繊維炭素繊維からなる織物をフィラーとして有する複合材料を示す図（モデル図）である。

【図７】



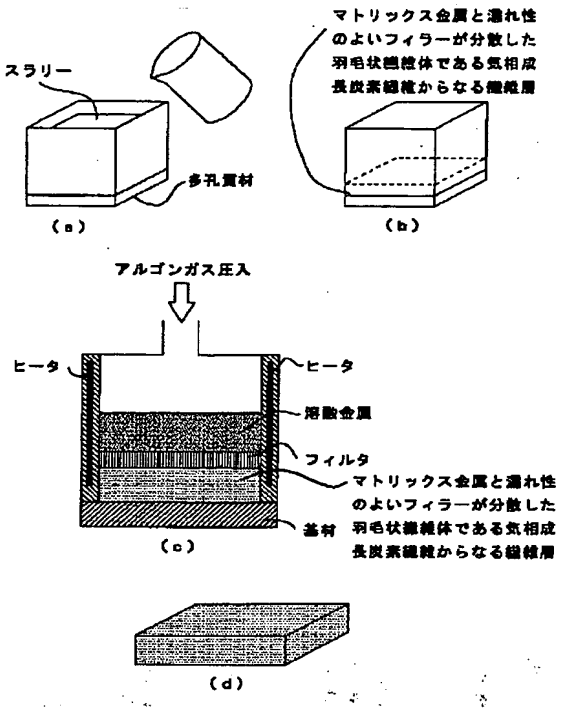
【図１】



【図２】

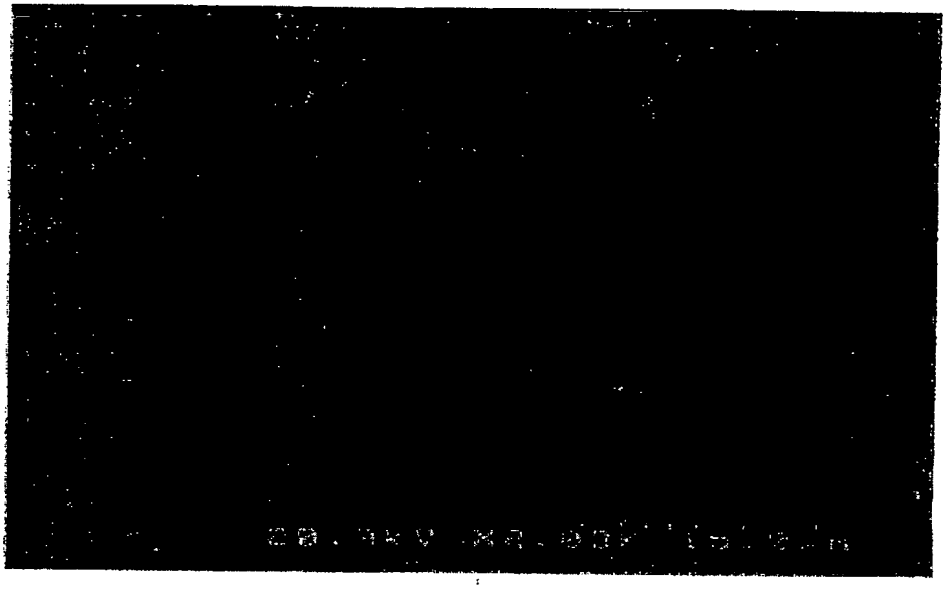
【図３】

【図４】

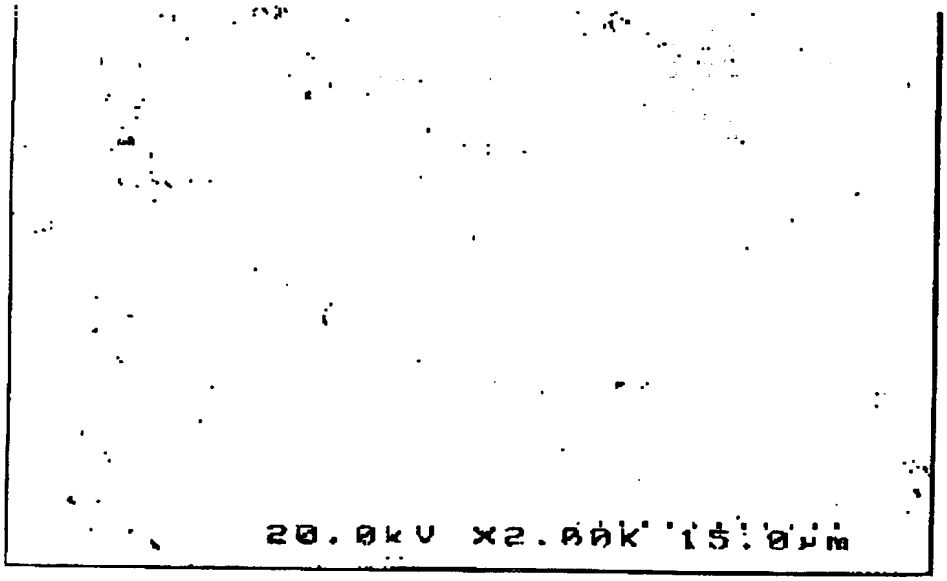

スラリー
多孔質材
(a)
マトリックス金属と濡れ性のよいフィラーが分散した羽毛状繊維体である気相成長炭素繊維からなる繊維層
(b)
アルゴンガス圧入
ヒータ
ヒータ
溶融金属
フィルタ
マトリックス金属と濡れ性のよいフィラーが分散した羽毛状繊維体である気相成長炭素繊維からなる繊維層
基材
(c)
(d)

【図５】

(a)

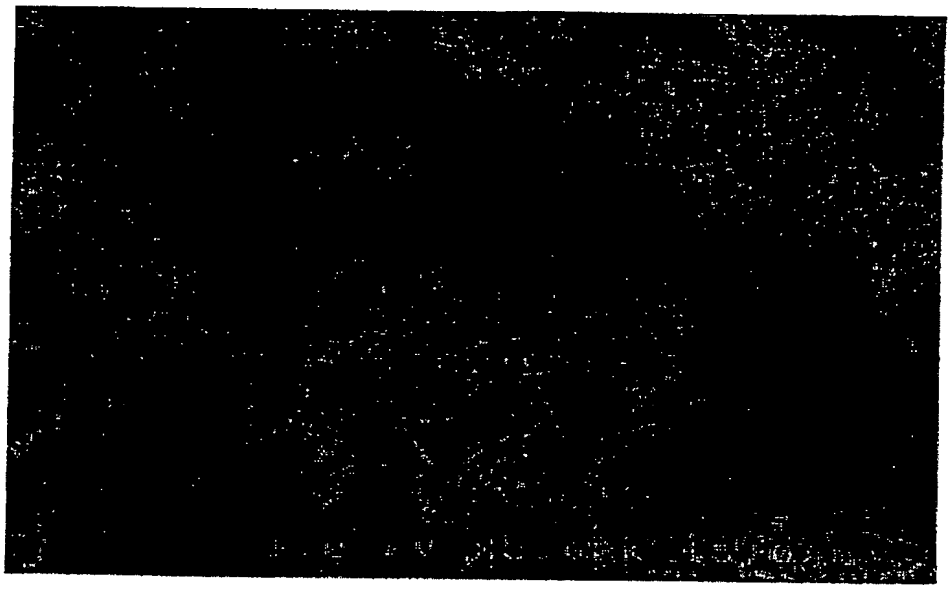


(b)



【図６】

(a)



(b)

フロントページの続き

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